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Government by experiment? Global cities and the governing of climate change

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Abstract

In this paper, we argue for an approach which goes beyond an institutional reading of urban climate governance to engage with the ways in which government is accomplished through social and technical practices. Central to the exercise of government in this manner, we argue, are ‘climate change experiments’ – purposive interventions in urban socio-technical systems designed to respond to the imperatives of mitigating and adapting to climate change in the city. Drawing on three different concepts – of governance experiments, socio-technical experiments, and strategic experiments – we first develop a framework for understanding the nature and dynamics of urban climate change experiments. We use this conceptual analysis to frame a scoping study of the global dimensions of urban climate change experimentation in a database of 627 urban climate change experiments in 100 global cities. The analysis charts when and where these experiments occur, the relationship between the social and technical aspects of experimentation and the governance of urban climate change experimentation, including the actors involved in their governing and the extent to which new political spaces for experimentation are emerging in the contemporary city. We find that experiments serve to create new forms of political space within the city, as public and private authority blur, and are primarily enacted through forms of technical intervention in infrastructure networks, drawing attention to the importance of such sites in urban climate politics. These findings point to an emerging research agenda on urban climate change experiments which needs to engage with the diversity of experimentation in

different urban contexts, how are they conducted in practice and their impacts and implications for urban governance and urban life.

Keywords

Urban, climate change, experiment, socio-technical, governance, government

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Introduction

Over the past two decades, cities have been recognised as playing a significant role in responding to climate change. In the policy arena, the number of transnational municipal networks engaged with the climate change issue has increased while their membership has diversified. At the same time, a growing range of actors, including national governments, UN-Habitat, WWF, Action Aid, Transition Towns, HSBC, the Clinton Climate Foundation, the Rockefeller Foundation and the World Bank, have sought to mobilise action in response to this 'urgent agenda' (WB 2010; see also UN-Habitat 2011). Within the research community, similar forms of network organisation are visible and scholarship is now being advanced on, for example, urban carbon accounting, assessments of urban metabolism, land use and land cover change, the interaction between urbanization, vulnerability and climate change, and policies and processes of governance which might best be able to address these challenges (Bulkeley 2010; Rosenzweig et al. 2011). The growing importance of this field of research is now recognised by the IPCC, which will include specific chapters on the urban dimensions of climate change in its 2014 Fifth Assessment. The city, so to speak, is now firmly on the climate change map.

There is, however, a paradox at the heart of this new found enthusiasm for the potential for urban responses to climate change. On the one hand, research suggests that the translation of political commitments and policy rhetoric into substantial and programmatic municipal responses has been limited. In essence, municipalities that have pursued a comprehensive, planned, approach to climate governance are few and far between and most have

encountered significant challenges related to institutional capacity and political economy (Bulkeley 2010; Gore et al. 2009; Kern and Alber 2008). On the other hand, the number of initiatives and interventions in cities which seek to address climate change appears to be rapidly proliferating. Whether this relates to eco-developments, new technologies, specific policies, community-based initiatives, corporate buildings, infrastructure renewal programmes or the like, climate change is increasingly attaching itself to the development, repair and maintenance of the city. In seeking to explain the possibilities of urban governance, attention has focused on designing policy processes to improve urban planning and addressing issues of limited capacity. These are very real challenges, particularly in low-income urban contexts where vulnerability to the effects of climate change is most significant and the ability to cope most limited. Interventions and initiatives which fall outside of this framework are regarded as curiosities – nice to look at but of little substantial value. However, we wish to suggest that by sidelining such interventions, such accounts overlook the ways in which governing is accomplished and challenged. In this paper we bring geographical perspectives on urban governance to argue that rather than occupying the margins of urban responses to climate change, such interventions can be regarded as *climate change experiments* which are central to the ways in which mitigation and adaptation are being configured and contested.

In order to establish the basis upon which we can begin to understand the role of climate change experiments in urban governance and to chart future research directions in this field, this paper sets out to do two things. First, we consider how we can conceptualise experiments in the urban context. In the first part of the paper, we consider how the emerging landscape of urban climate governance is currently theorized and offer an

alternative reading which draws attention to the ways in which governing is conducted through multiple sites and forms of intervention. Focusing on those interventions which can be regarded as 'experimental', we then examine three different perspectives which offer insights into the nature and dynamics of climate change experiments: in terms of governance experimentation; socio-technical experimentation; and strategic experimentation. Rather than delimiting different types of experiment, these perspectives offer alternative theoretical lenses through which to consider and evaluate climate change experiments. Through drawing across these literatures, we argue that experiments serve as a means through which the governing of climate change in the city takes place, opening up both the sites and processes through which it is accomplished.

Having established the grounds upon which climate change experiments may be theorized, our second aim in this paper is to establish the extent to which climate change experimentation is taking place in cities globally. Much of the literature on urban climate governance focuses on single or small sets of case-studies (Bulkeley 2010). In seeking to establish the basis for a new area of research – urban climate change experiments – we suggest that it is critical to understand the extent to which it is relevant in diverse urban contexts. While limited by the depth and detail of analysis which it can provide, survey methodologies enable such scoping work. In order to lay this groundwork, in the second part of the paper, we outline the findings from a survey of climate change experiments taking place in one hundred global and mega-cities. We chart where, in which sectors, and through which means experimentation is taking place, and consider the actors and interventions involved. Our analysis suggests that while experimentation is ubiquitous, it is clearly structured through different sectors, interventions and places, with significant

implications for how urban responses to climate change are emerging worldwide. In conclusion, we argue that analyses of urban climate governance need to engage with the multiple and sometimes unlikely places through which governing is conducted and the consequent implications both for how we know and govern the city (McFarlane 2011). We set out an agenda for this field of research, and of the importance of developing the analysis of urban climate change experiments in order to understand how, why and with what implications experiments intervene in the city, and their potential role in processes of urban transition.

Climate Governance and Urban Experiments

The earliest urban responses to climate change took place in the late 1980s and early 1990s. Municipalities at this time tended to adopt a structured way of designing policy, advocated, for example, by ICLEI's Cities for Climate Protection programme, in which baseline assessment of greenhouse gas emissions was undertaken, targets set, plans devised, and policy implemented (Betsill and Bulkeley 2007; Bulkeley 2010). However, recent analysis suggests that "numerous cities, which have adopted GHG reduction targets, have failed to pursue such a systematic and structured approach and, instead, prefer to implement no-regret measures on a case by case basis" (Kern and Alber 2008:4; see also Jollands 2008). This is perhaps not surprising, for as municipal authorities sought to engage with an issue which lay outside their core competencies they turned to an enabling mode of governance which depended on discrete pots of financial assistance and on 're-framing' climate change as an issue related to core agendas (concerning financial savings, congestion, air pollution, urban planning and so on), which resulted in a fragmented, 'case-by-case' approach to the

development of initiatives and measures (Bulkeley and Kern 2006; Sanchez-Rodriguez et al. 2008). Further such interventions were shaped by windows of opportunity (e.g. sporting events, disasters, infrastructure renewal programmes) and funding (e.g. C40 Better Buildings Programme), again creating a patchwork of responses. With the increasing role of other urban actors in governing climate change, the nature of the private authority which they bring to bear has also resulted in discrete forms of intervention in the city, such as specific (iconic) buildings, demonstration projects undertaken in partnership with municipal authorities, and different forms of community organising. The ubiquity of climate change as a discourse ensures that it is attached to a range of different projects, from flood protection measures to tree planting schemes, which may have previously existed outside of the climate arena, adding to the fragmented landscape of urban responses.

For some, this landscape is indicative of a lack of capacity to co-ordinate and deliver an integrated, planned approach for urban climate governance (e.g. Corfee-Morlot et al. 2011). For others, it may suggest that as “the *idea* of climate change is now to be found active across the full parade of human activities, institutions, practices and stories” (Mike Hulme, 2009: 322), urban responses to climate change simply exceed what we might term governance. Moving beyond an institutional account of governance to one which regards governing as a process orchestrated by “the will to improve: the attempt to direct conduct or intervene in social processes to produce desired outcomes and avert undesired ones” (Murray Li 2007a: 264) casts these issues in a different light. If governing is achieved through “modes of action, more or less considered and calculated, that were destined to act upon the possibilities of action of other people” (Foucault 2000: 341), this requires “the construction of certain truths and their circulation via normalizing and disciplining

techniques, methods, discourses and practices that extend beyond the state and stretch across the social body” (Rutherford 2007: 293). Rather than finding coherence in the process of policy making and its implementation, or regarding urban responses which take place beyond the formal purview of institutionalised arenas of governance as void of governmental effect, such a view of the ways in which power is conducted point to the critical role of the manifold sites techniques and practices through which conduct is shaped. As such, an “explicit, calculated programme of intervention (of government) ... is not the produce of a singular intention or will. It draws upon and is situated within a heterogeneous assemblage” of artefacts, knowledge, authority, agency and so on (Murray Li 2007b: 6). This implies that interventions matter in both a social and a material sense, and that they may provide a critical means through which particular forms of governing assemblage are established and maintained within an urban milieu (Bulkeley and Schroeder forthcoming; McFarlane 2011). Rather than viewing climate change initiatives as the ‘spillover’ effects of a governance system lacking capacity, this analysis suggests instead that such interventions are a critical means through which governing ‘as normal’ takes place.

There are, therefore, two related reasons why understanding urban climate governance is, not only a matter of analysing the development of strategy, discourse and policy. First, empirical evidence points to the multiple forms of urban response that are taking place which exceed this categorisation. Second, a theoretical position which regards governance as conducted through governmental rationalities and practices suggests that such forms of response may be central to the ways in which governing is accomplished. This suggests that analysis in this field needs to consider how, why, and with what implications, projects and measures undertaken in the name of climate change may intervene in the city. We suggest

that such interventions might fruitfully be considered in terms of ‘experiments’, partly in order to signify their potential but more significantly to recognise their often tentative nature, the sense of ‘testing’ or establishing (best) practice that frequently accompanies their development, and the ways in which they are used as a means of supporting or contesting knowledge claims and discursive positions (see also Evans 2011, McFarlane 2011). Here, we do not use experiment in the formal scientific sense of the term but rather to signify purposive interventions in which there is a more or less explicit attempt to innovate, learn or gain experience.¹

In seeking to understand the nature and implications of urban climate change experiments, we suggest that there are three sets of literatures which are of relevance: those concerning governance experiments; those relating to the nature of socio-technical systems and the ways in which they might be transformed; and those which examine purposive or strategic urban experiments. Rather than describing distinct types of experiment, the different theoretical perspectives developed in each of these accounts provide us with distinct insights which can be brought to bear in our analysis of urban climate change experiments. In the rest of this section, we discuss each of these perspectives in turn, before analysing their collective implications for the study of climate change experiments in the city.

Experimentation Take I: from policy laboratories to governance experiments

¹ Experiment is a complex word, conveying several different meanings, including the familiar scientific sense of ‘testing’ a hypothesis under controlled conditions, but also, and more importantly for our purposes, it can mean a ‘tentative procedure’ and the ‘action of trying anything, putting it to proof’, as well as ‘to have experience of ... to feel’ (OED Online). To be experimental is about the process of experience, of bearing ‘witness’ (OED Online) and is a tentative, unfolding, process, rather than necessarily implying something novel or innovative.

A first take on the dynamics and implications of urban experimentation can be found within a body of literature concerned with the role of policy innovation at the sub-national level. Writing in 1932, Louis Brandeis famously observed that the US states may function as ‘laboratories of democracy’, by “testing new ideas and policy proposals, gradually building a record of policy innovation that can be tapped by national officials when the time is ripe” (Aulisi et al. 2007: 5). Subsequently, sub-national governments have been studied as ‘policy laboratories’ and places of experimentation such as in work by Rabe (2007) related to climate change innovations, including renewable energy feed-in tariffs and cap and trade schemes. An alternative account of experimentation in the policy sphere is offered by Hoffman (2011) who argues that the twin pressures of disillusionment with the process of international policy negotiation and the fragmentation of political authority has created both the political space and the imperative for an era of ‘governance experimentation’ (Hoffman 2011). Hoffman defines climate governance experiments in three ways: they explicitly seek to make rules (in the broadest sense including norms, discourses etc.) that “shape how communities respond to climate change”; they are independent of the international process of climate governance or national regulation; and they cross jurisdictional boundaries (Hoffman 2009: 3-4). This third criteria, he suggests, is a practical measure to constrain the number of governance experiments under analysis, because of the proliferation of climate action plans at the municipal level, but also a conceptual matter, necessitated by a focus on “examining experiments that are rule-making endeavours in non-traditional political spaces” (2009: 4). However, the conceptual argument that the existing structures of municipal governance limit the extent to which urban climate change initiatives can be regarded as ‘experimental’ is moot. As some of the literature on urban

responses to climate change has found, climate governance initiatives are precisely taking place outside of the existing channels of political authority where existing rules concerning how to govern are limited (for example, Bulkeley 2005; Gustavsson et al. 2009).

On this basis, urban interventions could be considered as part of the phenomenon of governance experimentation which Hoffman documents and which has gathered pace since the early 2000s. Within this context, Hoffman (2011) suggests, actors are motivated to devise and implement experiments on the basis of profit, out of a sense of urgency, through a desire to expand authority and claims to resource, and as a form of ideological expression. In relation to the urban governance of climate change, these motivations are clearly visible as actors seek to develop 'win win' responses to climate change, argue that cities can act more quickly on this issue than national governments, stake claims for resources based on their potential to mitigate or adapt to climate change and use the issue as a basis for political contestation with other levels of government (Hodson and Marvin 2009). While et al. (2010: 82) suggest that processes of eco-state restructuring are now focused on 'carbon control', creating a "distinctive political economy associated with climate mitigation in which discourses of climate change both open up, and necessitate an extension of, state intervention in the spheres of production and consumption." This politics of carbon control grounds the "the calculative practices of urban management" in new forms of financial strategy and economic development, a process developed around "experiments in the reterritorialisation of governance at the city-regional scale" (While et al. 2010: 87). In a similar vein, Hodson and Marvin (2009: 195-196) suggest that issues of climate change mitigation and adaptation are becoming a key strategic concern for urban authorities, facilitated through the restructuring of the state and the creation of 'new state spaces'. As

has been documented across a broad body of urban and political scholarship, the remaking of political authority has taken place through “processes of state territorial restructuring, the remaking of bordering regimes, the emergence of new modalities of place-making and the consolidation of new forms of networked governance”, in turn leading to the rescaling of the state and to new forms of statehood (Brenner 2009: 125) as well as non-state based arenas of political authority (see also Brenner 2004, Bulkeley 2005). For Hodson and Marvin, these dynamics are leading to new forms of urban climate governance as the “the world’s largest cities” begin “to translate their strategic concern about their ability to guarantee resources into strategies designed to reshape the city and their relations with resources and other spaces” (Hodson and Marvin 2009: 200). Taken together, these analyses suggest that the roots of urban experimentation lie not only in shifts in the international governing of climate change, but also in the restructuring of the (local) state. Analyses of the geographies of urban climate change experiments might therefore seek to examine whether differences can be discerned in the nature and type of experimentation in relation to variations in the political and economic dynamics of urbanisation, or in terms of who is leading and funding experimentation. The potential importance of international, national and local climate policy drivers in shaping urban experimentation might also be evident, in terms for example of when and where experimentation is taking place and in terms of the ways in which climate change is framed and addressed – through, for example, carbon markets, new energy technologies, or forestry projects. As this suggests, such experiments are mediated by and orchestrated through the urban infrastructure systems through which climate change responses are conducted. This, in turn, suggests that conceiving of urban climate change experiments through such an analysis of governance terms misses their socio-

technical nature, and the ways in which governing takes place through the everyday and the material practices of urbanism.

Experimentation Take II: niche innovation and regime transformation

One set of debates which has explicitly considered the role of experiments in socio-technical terms concerns the emergence and transformation of (large technical) systems. Socio-technical systems are regarded as co-produced by technical and social components (Hughes 1987), which present a resistance to change, or inertia, which predetermines fossil-fuel based development pathways and carbon lock-in (Unruh 2002). Recent work has adopted a 'multi-level' perspective for understanding such systems, comprising of the landscape, which "provides the macro-level structuring context", socio-technical regimes which "constitute the mainstream, and highly institutionalised, way of currently realising societal functions", and niches, relatively protected spaces within which innovation and experimentation takes place (Smith et al. 2010: 440). Change in socio-technical systems is achieved through alignments between different levels – for example, outsider niches may 'break through' when incumbent regime actors fail to re-orient their efforts in response to landscape pressures (Geels 2007). This may result in intra-systemic adaptation ('reproductions' or 'transformations') (Geels and Kemp 2007), or in 'transitions', "major technological transformations in the way societal functions such as transportation, communication, housing, feeding are fulfilled" (Geels 2002: 1257).

Niches are regarded as critical to the process of socio-technical change. Reflecting the history of the concept within the field of innovation studies, niches are primarily regarded in

technology or market terms and as sheltering new forms of technological innovation. Such technological niches can be “made operational through (a series of) protected test beds such as pilot and demonstration plants where technologies are applied in a societal setting for the first time” (Raven 2007: 2391). In response to this technological focus, other authors have begun to draw attention to the importance of *social niches* in the dynamics of socio-technical systems. Research has mainly focused on social niches emerging outside the mainstream, analysing “bottom up experiments with environmental technology by citizen groups and/or NGOs, operating outside the institutional structures of firms and governments” (Hegger et al. 2007), also termed “grassroots innovations” (Seyfang and Smith 2007), in which novel forms of social organisation co-evolve with technological artefacts and practices to create alternative forms of service provision. Rather than developing in response to the creation of strategic opportunities within the dominant regime, social niches are conceived as emerging organically, operating in the margins of mainstream regimes and may gain much of their momentum precisely because of their opposition to dominant values and practices. There is, however, no a priori reason why social niches should be analytically confined to marginal economic and political spaces. Innovative forms of social organisation involving powerful actors (such as governments, firms, donor organisations) might also be conceived as ‘social niches’ in which socio-technical co-evolution can occur. For example, Smith (2007: 439) finds that “intermediate” projects including third sector organizations, individual pioneers, as well as mainstream building companies that seek to “inculcate in the mainstream some of the principles and framings held in the green niche” are important in challenging dominant regime practices.

Across these technical and social perspectives on niche development, experimentation is regarded as critical to the stability and dynamics of socio-technical regimes. However, the ways in which experimentation is conceived vary. Within historical and contemporary analyses of the emergence of technological niches, experimentation is regarded primarily as a process of innovation. Brown and Vergragt (2008: 112) point to the creation of ‘bounded socio-technical experiments’ as an explicit response to (urban) sustainable development challenges where “at least some of the participants ... explicitly recognize the effort to be an experiment, in which learning by doing, doing by learning, trying out new strategies and new technological solutions, and continuous course correction, are standard features.”. Alongside social learning, experimental projects are seen to provide space for interactions between actors and for building social networks, enabling the articulation of expectations and visions and the alignment of heterogeneous resources including practical knowledge, tacit skills, tools, machines, money and people (Geels and Raven 2006). Through these processes – learning, building social networks, creating expectations and bricolage – experimental projects are seen as critical in *creating* niches, which can, given appropriate conditions, challenge regime dominance.

Debates surrounding socio-technical systems and their transformations provide insights into the processes and potential of experiments, reinforcing our argument that seemingly discrete interventions may have wider effects and are a critical means through which governing climate change could be achieved. These insights suggest that in examining the nature and dynamics of urban climate change experiments, analysis needs to consider the forms and purposes of such interventions within wider socio-technical systems, include forms of social experimentation alongside technically-orientated interventions, and to

analyse the processes through which experimentation takes place on the ground. However in stressing the 'protected' nature of such niche spaces and the process of experimentation as predominantly one of learning, to date, such accounts have been short on analyzing the political economy of experimentation, have underplayed conflict as a means through which experimentation arises, and have neglected the ways in which such interventions enact or challenge existing power relations. This is particularly problematic in the context of urban sustainability, for as Smith (2007: 436) argues, "green niches", most notably grassroots innovations, are "constructed in opposition to incumbent regimes. They are informed, initiated and designed in response to sustainability problems perceived in the regime." Unlike the emphasis on the creation of protected spaces and learning processes, literatures on urban governance suggest that climate policy experiments can often take place in exposed sites (e.g. conflicts over land use planning), involve competing (discourse) coalitions, and are structured by relations of power and strategic practices, raising questions about the extent to which the development of niches can lead to broader systemic change. This in turn suggests that in taking research in this field forward, the ways in which experiments are, and are not, able to shape different forms of urban transition will be a critical area for analysis.

Experimentation Take III: living laboratories and the design of urban futures

If the urban has been an implicit arena for experimentation in the previous two sets of debates, a third area of discussion locates experimentation firmly in the city. Cities have been arenas in which many different kinds of utopian ideals – from the garden city and 'machines for living' to 'sustainable communities' – have been tested. Historical studies of planning have emphasised the construction of the "city of imagination" as been the testing

ground for new forms of urbanism to realise, not only alternative visions of the built form but also, alternative visions of society (Hall, 2002). In the context of globalisation, the link between cities and creativity and innovation has been emphasised in studies looking at the concentration of labour, institutional networks, resources and infrastructures in city-regions associated with the emergence of “social and cultural economies of agglomeration” which also support economic globalisation (Jonas and Ward, 2007; 171). We concur with Jonas and Ward that we need to look beyond a functional understanding of cities in the global economy, highlighting the constitutive role of urban politics, especially in generating social, cultural and material spaces of innovation. The plethora of ‘eco-city’ initiatives is testament to one form of the renewed attempts to experiment in designing urban futures. A recent survey found that “innovative eco-city initiatives are as likely to be found in China, Kenya, Japan, South Korea, and South Africa, as in Canada, Germany, Great Britain, Sweden, and the United States. Some of the most original eco-city projects are currently in planning or under construction in the Middle East and East Asia” (Joss 2010: 242). Here, the focus of innovation is squarely technical, with three-quarters of projects emphasizing “technological innovation as means of achieving eco-city development” (Joss 2010: 246). Such projects often embody a passive sense of experimentation, where an urban context functions as the background for particular interventions and function as a means for “testing existing forms of knowledge and technology” rather than giving rise to explicit processes of learning or efforts to redirect urban development (Evans 2011: 225).

The experimental quality of the urban seems therefore to have become the focus for recent strategic efforts to address environmental problems. In a recent analysis of the emergence of forms of resilience and adaptive governance as a response to climate change, Evans

(2011: 226) argues that cities have “always been experimental, in the sense that new knowledges are tested in order to alter the way in which the city is administered” (see also McFarlane 2011). He suggests that a growing policy rhetoric which envisages cities as self-regulating, socio-ecological systems is reinvigorating such approaches by extending scientific practices of experimentation into the city while at the same time emphasising the need to ‘steer’ rather than ‘manage’ urban systems in ways which require both more innovation and an appreciation of the open-ended nature of urban interventions (Evans 2011; see also Evans and Karvonen 2010). In his analysis of the emergence of ‘living laboratories’, research projects designed to test particular forms of sustainability intervention with social and natural urban systems in real places and real time, Evans (2011) documents the ways in which the relationship between science and policy, and indeed what these categories entail, is challenged by such forms of experimentation. In this reading, climate experiments are regarded primarily as purposive interventions undertaken by research and policy communities and associated with a “particular style of adaptive governance that seeks to feed environmental monitoring back into a management process”, albeit one which is more open-ended and adjusted in response to the emergent properties of the system (Evans 2011: 255). The notion that cities can provide laboratories for ‘live’ experimentation is not confined to particular research projects. In their analysis of the emerging hydrogen economy in London, Hodson and Marvin (2007: 317) show that the EU CUTE programme was founded on the basis of the need for ‘real life experimentation’ with multiple fuel cell buses and their infrastructure in “a series of highly ‘visible’ cities, to be ‘tested out’ under a ‘variety of conditions’”, a “test bed” approach that also appealed “to the competition amongst ‘world’ and ‘European’ cities in attracting such demonstrations.” This is not a process that goes uncontested, for “local residents strongly resisted the ‘dropping-in’ of

hydrogen economy by BP into their local context” (Hodson and Marvin 2007: 318). However, the ability to frame such experiments as in the international and national interest, of producing and reproducing “London as the ‘national exemplar’” served as a means through which this conflict was diffused (Hodson and Marvin 2007: 321).

In contrast to accounts of niche emergence and socio-technical regime transformation, analyses of the social, scientific and political basis of urban experiments, sometimes explicitly as ‘living laboratories,’ demonstrates the strategic and often contested nature of the processes involved. In such analyses, experiments are the means through which discourses and visions concerning the future of cities are rendered practical, and governable. In this sense, we concur that “climate experiments are where governance is *located*; they represent the practical dimension of adaptation [and mitigation] – what happens in practice, ‘on the ground’, when policymakers, researchers, businesses and communities are charged with finding new paths” (Evans 2011: 225; emphasis added). However, we would caution against assuming that such processes entail processes of learning within an open-ended, adaptive governance framework (Evans 2011). As Hodson and Marvin (2007) detail, such interventions can be strategic and purposive, designed to further particular interests at the expense of others and to diffuse potential opposition. Indeed, as Evans notes (2011: 233), “if sustainability comes down to letting 1000 experimental flowers bloom, then it matters who gets to experiment, and how.” In this context, understanding the political economies of experimentation, by whom and on whose behalf they are enacted, through which modes of governance (Bulkeley and Kern 2006), and to what ends, becomes an ever more critical component of understanding the governing of climate change (Bulkeley and Newell 2010).

Governing with experiments

These three perspectives on the nature and role of experiments in the governing of climate change provide a means through which we can examine the changing landscape of urban climate governance and analyse the ways in which governing is accomplished. Importantly, each of these perspectives rejects the commonly-held view that such interventions ‘stand alone’ in the city. Rather, experiments are regarded as a means through which policies diffuse, as symptomatic of changing structures of political authority and opportunity, as a means for effecting socio-technical transformations, and of knowing and managing cities. In this regard, experiments may be regarded as curiosities not because of their status as trivial niceties, but rather because of the potential “careful or elaborate workmanship” (Oxford English Dictionary online) that has gone into their design and maintenance.

Drawing on these three perspectives, we suggest that experiments can be considered as part of the broader phenomenon of climate governance experimentation documented by Hoffman (2011), so that we might expect to find similar dynamics in terms of the histories, rationalities and practices of urban climate experiments as is evident in other governance arenas, a set of variables that we investigate in more detail below. However, we argue that such forms of experimentation are also intimately related to the ways in which urban authority is being restructured and to the strategic responses to climate change emerging through processes of urban political economies (Hodson and Marvin 2009, 2010; While et al. 2009). This suggests that an analysis of urban climate change experimentation at the broad scale might expect to find differences in the nature of experimentation emerging in

different kinds of cities, in different global regions, and where different urban dynamics – of growth, politics, social change and so on – are taking place.

This first perspective, on ‘governance experimentation’, begins to provide the building blocks for thinking through the political economy of climate change experiments. However, we suggest that there is a need to marry any concept of ‘governance experimentation’ with an explicit understanding of governing as accomplished in material, practical terms. Insights from literatures on socio-technical systems and the role of niches and experiments in creating new spaces with the potential for transformative change are valuable in this regard, but still have to be systematically explored in the urban context (Bulkeley et al. 2011). In particular, the processes through which niches and experiments come to matter require revision in light of the alternative frameworks of experimenting offered here. Rather than creating protected spaces through which innovation can be fostered and system change developed, experiments could provide grist in the urban mill, creating conflict, sparking controversy, offering the basis for contested new regimes of practice. As the literatures on ‘living laboratories’ suggest, urban experiments are conducted by a range of actors, and to various purposes. This is not to suggest that experimentation may not form a critical part of the dynamics of urban transition, but it is to raise questions about how and with what effect climate change experiments are able to shape such trajectories and indeed about how we should conceive of the notion of transition itself. To this end, rather than regarding experimentation as an open-ended process orchestrated by the dynamics of learning the city, or outside of the proper ‘governance’ of climate change in the city, this analysis suggests that experiments are critical sites of urban climate politics.

Climate change experiments and global cities

Our argument thus far suggests that climate change experiments are a critical means through which to understand the nature and implications of urban responses to this ‘urgent agenda’ (World Bank 2010). Taken together, the perspectives above are suggestive of some of the potential emerging dynamics and impacts of urban climate change experimentation. Yet we have little sense of how far climate experimentation is taking place globally. The second purpose of this paper is to begin to scope out empirically the global dimensions of urban climate change experimentation. In this section, we present the findings from a survey of the climate change experiments being undertaken in one hundred cities, as one method that we have deployed in order to chart this emerging landscape². First, we briefly introduce the database, the methodologies used and its limitations, before outlining some of the key findings³. Drawing on the insights derived from our reading of the literature on experiments presented above concerning the need to address both the political and the socio-technical nature of experiments, as well as their scope and purpose, we focus this analysis on three aspects. First, in order to ascertain the extent to which urban climate change experiments reflect the broader trends of ‘governance experimentation’ in the climate arena identified by Hoffmann (2011) and to assess the implications of different urban dynamics on processes of experimentation, we examine when and where these

² In addition to this survey methodology, our research has involved five case-studies of urban climate change experiments which each include a mixed methods approach involving semi-structured interviews, documentary analysis, participant observation and photography. The fieldwork and analysis of these case-studies is currently in progress.

³ The database contains a large volume of material, only some of which is presented here. Additional analysis from this data source is currently being prepared for publication.

experiments occur. Second, we focus our attention on the different socio-technical systems in which these experiments seek to intervene, in order to further evaluate the ways in which urban experimentation is connected to the broader drivers of (urban) responses to climate change identified in the literature above (carbon markets, opportunities for resource security) while also beginning to reveal the relationship between the social and technical aspects of experimentation. Finally, in keeping with the analysis offered above of ‘strategic’ experiments, as well as those accounts which point to the importance of the restructuring of the state, we detail the actors involved in the governing of experiments and the extent to which new political spaces for experimentation are emerging in the contemporary city.

Gathering experiments

In designing our database we adopted Hoffman’s general principle that experimentation takes place beyond existing channels of policy-making (e.g. formal processes of plan making or policy documents), and developed three criteria to define an urban climate change experiment as: 1) an initiative or intervention constitutes an experiment where it is a purposive attempt to reconfigure one or more socio-technical system for specific ends; 2) this is a climate change experiment where the explicit purpose is to reduce greenhouse gases or to adapt to the effects of climate change; and 3) it is urban in so far as it is conducted by or on behalf of an (imagined) urban community. The selection of 100 cities involved ranking 250 cities according to four different criteria and two additional weightings, and adding the subsequent scores to select the 100 cities with the highest aggregate scores. The four criteria used were: 1) total population in 2007; 2) density in 2007; 3) GDP in 2005

(all three determined using data from the website City Mayors⁴); and 4) role of the city in international city networks using the roster of World Cities of the Globalisation and World Cities Research Network (Beaverstock et al. 1999). The two weightings were introduced to favour the inclusion of cities which participate in climate change city networks (C40 and ICLEI) and to favour cities which are ranked as most vulnerable to climate change (Nicholls et al. 2008; Stern et al. 2006; UN-HABITAT 2008). Figure 1 shows a map with the final selection of cities

Insert Figure 1 here

Having established the sample of 100 global cities and the criteria upon which to assess urban climate change experiments, data gathering was conducted from June 2009 – June 2010, through the review of policy literature, grey material, websites and academic sources. This search was conducted in five different languages (English, Spanish, Portuguese, French, and German), with each city being afforded roughly the same amount of research effort (between one and two days) as a means of ensuring a fair level of coverage. In each city, both mitigation and adaptation experiments were recorded. In addition, to reflect the diversity of mitigation experiments, these were classified into five key sectors where mitigation initiatives most commonly occur: urban infrastructure; built environment; urban planning; transportation and carbon sequestration (UN-Habitat, 2011). For each experiment, information was recorded in relation to five key questions: (a) what type of social or technical experiment is being undertaken in which sector; (b) where is it taking place; (c)

⁴ City Mayors is an international think-tank for urban affairs. City Mayors Urban Statistics are available at http://www.citymayors.com/sections/rankings_content.html (last accessed 29/05/09)

when was it initiated and completed; (d) who is involved in leading action, partnerships, and funding; and (e) how is it conducted. Rather than providing a comprehensive assessment of urban climate change experiments, either in terms of their global extent or indeed of all such interventions taking place in any one city, the intention is for the database to provide a snapshot of the landscape of urban climate change governance from the perspective of experiments. This landscape is rapidly evolving and difficult to track over time. As with other methodologies reliant on the use of secondary data and working in several (but clearly not all) major relevant languages, issues of translation and interpretation are also significant. Some experiments promise more on paper than they deliver and significant experiments may be missing from this account. Given that this is the first global assessment of its kind, we also lack an understanding of what the 'universe' of experiments might look like, and therefore the extent to which this sample is biased to one or other aspect of experimentation. Bearing these caveats in mind, this approach is valuable in providing both an initial documentation of the nature of urban climate governance conducted through experiments and an internationally comparative assessment of the rise of experimentation, its socio technical nature and how it is governed.

When and where are climate change experiments taking place?

In keeping with the analysis offered by Hoffman (2011), we find that urban climate change experiments are a relatively recent phenomenon with 79% initiatives starting during the past five years and only 5% preceding the Kyoto Protocol. This suggests that urban experiments may indeed be part of the wider process of governance experimentation.

However, in contrast to assessments of governance experimentation and previous analyses of urban climate change governance, we find that experiments are not concentrated only in the ‘north’ but are most numerous in Europe, Latin America and Asia (Table 1). The relatively recent emergence of experiments and their presence in the ‘rapidly industrialising’ global south could imply that the norms, and opportunities, which are being generated by global climate governance are creating the opportunity for experimentation within these regions. At the same time, the fact that our sample focuses on large, often globally economically and politically significant cities, and the rapid pace of urbanization in these contexts, may be providing the opportunity for interventions at the urban level, especially with regard to urban infrastructure schemes, which are the most common form of experiment in our sample. Rather than being driven solely through the dynamics of ‘climate governance experimentation’, this suggests that regional differences in the processes and political economies of urbanism matter in terms of the extent to which emerging climate and carbon opportunities may be being pursued, in turn shaping the dynamics of urban climate change experimentation.

Insert Table 1 here

Where and how do experiments seek to intervene in socio-technical systems?

In terms of the sorts of experiments that are taking place in relation to mitigation, we have found that interventions in urban infrastructure are the most common, followed by the built environment, transport, urban planning and lastly sequestration (Table 1). Mirroring previous research findings on urban responses to climate change, we find considerably fewer experiments that specifically address climate change adaptation. There are therefore

clear distinctions in terms of the different elements of the climate change problem that are being addressed through experimentation. The focus on the built environment and infrastructure sectors is underpinned by an explicit interest in the production and consumption of energy (45% of all experiments have an energy focus). In the infrastructure sector, we find that energy-related projects dominate with 78% followed by 17% in the waste sector (which often are associated with energy provision from methane capture) (Table 2). New market opportunities in cities, including forms of low carbon investment and finance, the traditional association between energy saving and financial gain, together with emerging forms of ‘carbon control’ (While et al. 2010), may explain this focus.

Insert Table II here

Table 1 shows the regional trends by sector, pointing to clear differences in terms of how climate experiments are taking place. In Asia, North America and Africa climate change experiments most frequently take place in the urban infrastructure sector, while in Europe and Oceania the built environment sector dominates, again reflecting different urban political economies. Following the pioneering experiences of cities such as Curitiba, Bogotá and Mexico City, it is perhaps not surprising that most experiments in our sample from Central and South America concentrate in the transport sector. Carbon sequestration projects are relatively rare and are concentrated in Central and South America, driven by the interest in the Amazon (Brazil) and urban tree planting programmes (e.g. Bogota, Caracas, Lima, Quito). This is a clear difference from the world of climate governance experimentation, documented by Hoffmann, where forms of voluntary certification around forest carbon are a significant factor. Finally, most adaptation initiatives are concentrated in North America, following the trends of pioneering climate change adaptation programmes

in cities like Vancouver, Toronto and New York, and in Asian cities, particularly in coastal areas with previous experiences in disaster management (e.g. Tokyo).

Across the sectors, we find that experiments seek to intervene in an explicitly technical manner. Table 1 shows the overall predominance of technical innovation in most of the initiatives considered. Only in the carbon sequestration experiments was social innovation predominant, reflecting ongoing community and institutional engagement with issues surrounding forest conservation. Technical innovation is particularly predominant in the urban infrastructure sector, where programs dedicated to changing end-user behaviour are the least common. The significance of urban infrastructure systems and forms of technical innovation in climate change experimentation reinforces the notion offered by work on socio-technical regimes, niches and experiments that the material fabric of cities is critical site for intervention, and in turn for the governing of climate change in the city.

Who is governing climate change experiments?

Analyzing who governs experiments, how and with what effect is critical not only in terms of understanding the interests which they might serve, but also in terms of examining the basis for their emergence. Across the different sectors, the vast majority of urban climate change experiments are led by public sector actors (Table 3). Into the category of ‘public’ actor fall both municipalities and municipally-controlled utility companies, as well as dedicated urban planning and transport agencies, some of which may be ‘for-profit’ organizations. However, the ‘publicness’ of urban climate change experiments demonstrates that such interventions are indeed a critical means through which authorities

seek to govern. At the same time, urban climate experimentation is far from a solely public affair, with a plethora of private and civil society actors involved. Table 3 highlights, for example, the role of private actors in leading interventions in the urban infrastructure sector. 26 of the 39 initiatives in urban infrastructure led by the private sector are found in Asia, reflecting the increasing influence of ideals of private service provision that are prevalent in that region in relation to urban climate change governance and adding complexity to the notion that experimentation is a phenomenon driven only by processes within the global environmental governance arena. Table 3 provides further insight into these categorisations, showing the importance of local governments as the dominant public actor in terms of leading climate change experiments within the city. We observe that different types of actors predominate in different areas. For example, more than 50% of private-led projects are in urban infrastructure (53 projects) whereas more than 40% of the projects led by CBOs (which include grassroots groups and neighbourhood organisations) are in the built environment sector (14 projects).

Insert Table 3 here

When examining the *participation* of actors in urban climate change experiments, the picture becomes more diverse and more complex, with a strong presence of ‘partnership’ as a means through which experiments are conducted, in turn leading to the involvement of a wide range of private and community actors in conducting climate experiments (Table 3). Of all the experiments recorded, 296 (48%) involved some form of partnership. Local governments are the actors who led most partnerships (174, 59% of all partnerships); however when analysed separately, only 42 % of all the actions led by local authorities are in partnership. In contrast, initiatives led by CBOs, NGOs and private actors are most often

developed in partnership. These various roles being taken by state and non-state actors suggest in turn that processes of state restructuring and the emergence of new state spaces may be particularly critical to the development of experimentation in this field.

Insert Table 4 here

Examining those actors who form the partners, rather than leaders, in experiments, we see a higher diversity of the actors involved (Table 4). Private sector actors are the most common partner, with 169 experiments (27% of all experiments) conducted in partnership involving a private sector actor as a partner, though it should be noted that this ranges from large (utility) companies, financed by the CDM, to small firms, architectural practices and similar organizations that often have a strong sense of idealism and act as knowledge brokers or in the manner of advocates. Perhaps most surprising is the relatively limited participation of international organizations (e.g. World Bank, Asian Development Bank, UN) in urban climate change experiments and national governments, demonstrating the limited attention that issues of urban climate change have been given in the political agendas of such organizations. The most common form of partnership is between local authorities and private companies, but as Table 4 shows, a variety of other partnership arrangements are important, involving multi-level arrangements between different levels of government, partnerships between different private actors, and mechanisms to involve civil society organisations.

The multitude of different forms of partnership and institutional arrangement through which experiments take place signifies that such forms of intervention are creating new

political spaces within the city, establishing a means through which to govern climate change in the absence of a 'polity' (Hoffman 2011). At the same time, the emphasis on forms of technical innovation and material infrastructure systems suggests that such interventions provide a foci around which a heterogeneous mix of actors, ideas, artefacts, materials, resources are gathered and assembled. In this manner, they resemble at least some of the qualities of niches and living laboratories identified above. Interestingly, we find a very limited role for scientific or academic organisations in urban climate change experiments, unlike in other forms of living laboratories. At the same time it is important to note that while such an assessment can provide an overview of the landscape of climate change experiments and their global geographies, it does of course tell us little about how and why experimentation is taking place on the ground. Understanding the dynamics of such spaces, the ways in which they may resemble the learning associated with niches and laboratories or be orchestrated by other processes, the ways in which government is accomplished through experiment, and how they are practiced, requires alternative forms of in-depth analysis in particular through the use of detailed case-studies, which is currently an ongoing part of our work in this area.

Conclusions

Rather than being confined to policies and plans, we argue that governing climate change is taking place through particular forms of intervention – experiments – in the city. Regarded in this manner, experiments are not some side show to the main business of urban climate governance, but rather they are a critical means through which governing is accomplished. In this paper, we have sought to establish the basis upon which the theorisation of urban

climate governance experimentation might be undertaken, and to offer an initial assessment of the scope of this phenomenon in one hundred global cities. In undertaking this analysis, we find that experimentation cannot be adequately explained from any one existing theoretical perspective. In seeking to develop this field, we bring together insights from literatures on governance experimentation, socio-technical experimentation, and strategic experimentation in order to provide the basis for a new analysis which takes into account the political economy and socio-materiality of experimentation.

In undertaking our empirical analysis, we find that climate change experiments are a global and relatively recent phenomenon, but this trend is not homogenous. Instead, forms of experimentation appear to be linked with specific contexts of urbanization and of urbanism, suggesting that existing socio-technical systems establish the possibilities for intervention. Furthermore, experiments are focused on specific parts of urban socio-technical networks. The emphasis on energy intervention suggests that experimentation is frequently connected to issues of resource security and to the politics of 'carbon control' (Hodson and Marvin 2009, While et al. 2010), in turn implying that the drivers for experimentation go beyond the arenas of global environmental politics. At the same time, we find support for the argument that experimentation is taking place beyond the 'polity', as new forms of partnership, public, and private authority emerge in the design of urban political spaces through which climate change can be pursued. Here, experimentation is linked to the global processes of the shifting and blurring of public/private authority and the restructuring of the (local) state, but also to the emergence of new forms of institutional innovation emerging through experiments themselves. Through recognising experimentation as a site of politics, we are therefore able to bring together insights from literatures on global environmental

governance with analyses of the governance of urban socio-technical networks, and in particular to consider the emergence of new sites and intermediaries, which do not fit neatly established categories of producer and consumer, public and private, regulatory and economic and through which governing is accomplished (Moss, 2009).

Our analysis also supports a reading of experiments as fundamentally socio-technical. As the literatures on niches and living laboratories both suggest, experiments are critical sites through which visions of low carbon cities are created, networks built and learning enacted. However, we find that experiments are not confined to marginal or niche spaces – in either physical or political terms. Rather, a plethora of actors intervene in climate change experiments, including different forms of public authority, for whom they may serve as a means to demonstrate, cement and contest authority. Rather than operating as open-ended, learning processes, we find that experiments are often vested with particular interests and strategic purpose in the governing of the city. Nonetheless, forms of ‘grassroots’ experiments co-exist in the city alongside these strategic interventions, raising questions concerning the ability of otherwise marginal actors to use experiments as a means of advancing an alternative politics of climate change. The intervention of multiple actors, with various purposes, suggests that experimentation is used to advance divergent claims and values (perhaps simultaneously). This in turn raises the question as to whether, in this case, new forms of low carbon and climate resilient urban futures can truly be accomplished. While experiments may be used to establish particular forms of authority and carbon control, they are equally a tool for contesting established regimes. The dual nature and potential of experiments marks their role in reconfiguring the city but also their ambiguous character of experimental transitions.

Our analysis suggests that future research on urban climate governance needs, therefore, to engage with experiments as a potentially vital site through which governing is conducted. In so doing, we would suggest that there at least three areas which require sustained analytical attention. First, while our analysis has begun to establish emerging patterns of climate change experimentation in global cities, further work is required to examine the different kinds of experimentation which are emerging in distinct urban contexts, to identify the ways in which experimentation is structured through political economies operating at different scales and through different circuits of power and finance, and to consider whose interests are served through these processes. This will entail further analysis as to whether there are different typologies of experimentations, different forms of intervention or transition which they aim to produce and, if so, whether and with what effect these vary geographically. Second, further, in-depth, research is required to understand how, why and with what effect experiments take shape within specific urban contexts. Here, we suggest there is a need to consider the ways in which experiments emerge, are established and become part of urban responses to climate change and to consider how experiments intervene in urban life, for example what are the specific mechanisms whereby carbon control is produced, through which forms of narrative and practice, and the foreclosing of others, and with what consequence. Third, there is a critical need to consider the effects of experimentation. Such research might consider the effectiveness of experiments – their role in achieving climate and other urban goals. More importantly, however, research is also required to understand the ways in which such interventions serve the interests of some rather than others, and lead to new distributions of the risks and benefits of responding to climate change. Research in this area will also need to consider the effect that experiments have in relation to the

reconfiguration of urban socio-technical systems and whether they may lead to broader processes of transition and change in the city. The different theoretical perspectives introduced above suggest that experiments may be able to contribute to new forms of political architecture, socio-technical regime change, or create new ideals for urban futures. Understanding this potential will be a critical task for future research in this area, and may provide new insights for our understanding of the political geographies of climate change.

Bibliography

Aulisi A, Larsen J, Pershing J and Posner P 2007 Climate Policy in the State Laboratory: How States Influence Federal Regulation and the Implications for Climate Change Policy in the United States. World Resources Institute, Washington DC

Beaverstock J V, Smith R G and Taylor P J 1999 A roster of world cities. *Cities* 16: 445-58

Betsill M and Bulkeley H 2007 Looking Back and Thinking Ahead: A Decade of Cities and Climate Change Research. *Local Environment: The International Journal of Justice and Sustainability* 12: 447 - 56

Brown H and Vergragt P 2008 Bounded socio-technical experiments as agents of systemic change: The case of a zero-energy residential building. *Technological Forecasting & Social Change* 75: 107-30

Bulkeley H 2010 Cities and the Governing of Climate Change. 35: 229-53

Bulkeley H 2005 Reconfiguring environmental governance: towards a politics of scales and networks. *Political Geography* 24: 875-902

Bulkeley H, Castan Broto V, Marvin S and Hodson M 2011 *Cities and Low Carbon Transitions*. Routledge, London

Bulkeley H and Kern K 2006 Local Government and the Governing of Climate Change in Germany and the UK. *Urban Studies* 43: 2237-59

Bulkeley H and Newell P 2010 *Governing Climate Change*. Routledge, London

Corfee-Morlot J, Cochran I, Hallegate S, and Teasdale PJ 2011 Multilevel risk governance and urban adaptation policy. *Climatic Change*. 104: 169-197.

Evans J P 2011 Resilience, ecology and adaptation in the experimental city. *Transactions of the Institute of British Geographers* 36: 223-37

Evans J P and Karvonen A 2010 Living Laboratories for Sustainability: Exploring the Politics and Epistemology of Urban Transition. in Bulkeley H, Castan Broto V, Marvin S and Hodson M eds Cities and Low Carbon Transitions. Routledge, London

Foucault M 2000 The Subject and Power. in Faubion J ed Essential Works of Foucault 1954-1984, Volume 3. The New Press, NY 326-48

Geels F and Raven R 2006 Non-linearity and Expectations in Niche-Development Trajectories: Ups and Downs in Dutch Biogas Development (1973-2003). Technology Analysis and Strategic Management 18: 375-92

Geels F W 2002 Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31: 1257-74

Geels F W 2007 Analysing the breakthrough of rock [']n' roll (1930-1970) Multi-regime interaction and reconfiguration in the multi-level perspective. Technological Forecasting and Social Change 74: 1411-31

Geels F W and Kemp R 2007 Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. Technology in Society 29: 441-55

Gore C, Robinson P and Stren R 2009 Governance and Climate Change: Assessing and Learning from Canadian Cities. Fifth Urban Research Symposium "Cities and Climate Change: Responding to an Urgent Agenda", Marseille

Gustavsson E, Elander I and Lundmark M 2009 Multilevel governance, networking cities, and the geography of climate-change mitigation: two Swedish examples. Environment and Planning C: Government and Policy 27: 59-74

Hall P 2002 Cities of Tomorrow – Third edition. Blackwell Publishing, Malden, Oxford, Victoria.

Hodson M and Marvin S 2007 Understanding the Role of the National Exemplar in Constructing 'Strategic Glurbanization'. *International Journal of Urban and Regional Research* 31: 303-325

Hodson M and Marvin S 2009 Urban Ecological Security: A New Urban Paradigm? *International Journal of Urban and Regional Research* 33: 193-215

Hodson M and Marvin S 2010 Can cities shape socio-technical transitions and how would we know if they were? *Research Policy* 39: 477-85

Hoffman M 2009 Experimenting with Climate Governance. 2009 Conference on the Human Dimensions of Global Environmental Change - Earth System Governance: People, Places and the Planet, Amsterdam

Hoffman M J 2011 Climate Governance at the Crossroads: experimenting with a global response. Oxford University Press, New York

Hughes T 1987 The evolution of large technical systems. in Bijker W, Hughes T and Pinch T eds *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. MIT, Cambridge, MA 51-82

Jollands N 2008 Cities and energy- a discussion paper. OECD International Conference 'Competitive Cities and Climate Change'. OECD, Milan

Jonas A E G and Ward K 2007 Introduction to a Debate on City-Regions: New Geographies of Governance, Democracy and Social Reproduction. *International Journal of Urban and Regional Research* 31: 169-178

Joss S 2010 Ecocities: A global survey. *WIT Transactions on Ecology and The Environment* 129: 239-50

Kern K and Alber G 2008 Governing Climate Change in Cities: Modes of Urban Climate Governance in Multi-level Systems. Proceedings of the OECD conference on 'Competitive Cities and Climate Change'. OECD, Paris

McFarlane C 2011 The city as a machine for learning. Transactions of the Institute of British Geographers 36: 360-376.

Moss T (2009) Intermediaries and the governance of sociotechnical networks in transition. Environment and Planning A 41: 1480-1495

Murray Li T 2007a Practices of assemblage and community forest management. Economy and Society 36: 263-93

Murray Li T 2007b The Will to Improve: Governmentality, Development, and the Practice of Politics. Duke University Press, Durham

Nicholls R J, Hanson S, Herweijer C, Patmore N, Hallegatte S, Corfee-Morlot J, Château J and Muir-Wood R 2008 Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes. OECD Environment Working Papers, No. 1. OECD, Paris

Rabe B G 2007 Beyond Kyoto: Climate Change Policy in Multilevel Governance Systems. Governance 20: 423-44

Raven R 2007 Niche accumulation and hybridisation strategies in transition processes towards a sustainable energy system: An assessment of differences and pitfalls. Energy Policy 35: 2390-400

Rosenzweig C, Solecki B, Hammer S and Mehrota S 2011 Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network Cambridge University Press, Cambridge

Rutherford S 2007 Green governmentality: insights and opportunities in the study of nature's rule. Progress in Human Geography 31: 291-307

Sanchez-Rodriguez R, Fragkias M and Solecki W 2008 Urban Responses to Climate Change a focus on the Americas: A Workshop Report. International Workshop Urban Responses to Climate Change, New York City

Seyfang G and Smith A 2007 Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics* 16: 584 - 603

Smith A 2007 Translating Sustainabilities between Green Niches and Socio-Technical Regimes. *Technology Analysis and Strategic Management* 19: 427-50

Smith A, Voß J-P and Grin J 2010 Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy* 39: 435-48

Stern N, Peters S, Bakhshi V, Bowen A, Cameron C, Catovsky S, Crane D, Cruickshank S, Dietz S, Edmonson N, Garbett S-L, Hamid L, Hoffman G, Ingram D, Jones B, Patmore N, Radcliffe H, Sathiyarajah R, Stock M, Taylor C, Vernon T, Wanjie H and Zenghelis D 2006 Stern review: the economics of climate change. HM Treasury., London

UN-HABITAT 2008 State of the World's Cities 2008/2009 - Harmonious Cities. Earthscan, London, Sterling, VA

UN-Habitat 2011 2011 GRHS Cities and Climate Change. Earthscan, London

Unruh G C 2002 Escaping carbon lock-in. *Energy Policy* 30: 317-25

WB 2010 Cities and Climate Change: an Urgent Agenda. World Bank, Washington DC

While A, Jonas A E G and Gibbs D C 2010 From sustainable development to carbon control: eco-state restructuring and the politics of urban and regional development. *Transactions of the Institute of British Geographers* 35: 76-93

Table I: Emerging Geographies of Urban Climate Change Experiments

	Climate change experimentation sectors (number of experiments)							Regional distribution (%)	
Region	Adaptation	Built Environment	Carbon Sequestration	Transport	Urban Form	Urban Infrastructure	Total	Cities	Experiments
Africa	6	9	5	6	1	14	41	7	7
Asia	20	35	5	28	5	69	162	33	26
Europe	13	49	6	34	17	40	159	23	25
North America	22	36	5	18	9	46	136	22	22
Oceania	3	7	0	3	1	3	17	2	3
South and Central America	12	19	14	29	9	29	112	13	18
Total	76	155	35	118	42	201	627	100	100
Form of Innovation									
Social	46	110	14	85	33	177	465		
Technical	35	80	23	59	27	78	302		

Table II: Regional variations in urban climate change infrastructure experiments by sector (number of experiments)

<i>Region</i>	<i>Urban Infrastructure- Waste</i>	<i>Urban Infrastructure- Water</i>	<i>Urban Infrastructure- Energy</i>	<i>Urban Infrastructure Total</i>
Africa	4	0	10	14
Asia	13	1	55	69
Europe	4	1	35	40
North America	3	3	40	46
Oceania	0	0	3	3
South and Central America	10	6	13	29
Total	34 (17%)	11 (5%)	156 (78%)	201

Table III: Leadership and partnership in climate change experiments

Leading Actor	Adaptation		Built Environment		Carbon Sequestration		Transport		Urban Form		Urban Infrastructure		Total	
	Total number	Partners hips	Total number	Partners hips	Total number	Partners hips	Total number	Partners hips	Total number	Partners hips	Total number	Partners hips	Total number	Partners hips
Local government	46	8	101	41	16	7	96	44	27	15	127	59	413	174
Regional/state government	4	0	1	0	3	0	5	5	3	2	4	3	20	10
National Government	14	5	12	6	5	2	4	3	1	0	6	4	42	20
International Organisation	1)	1	0	0	0	0	1	1	0	0	2	0	4	2
Private Total	4	0	23	11	5	3	7	1	5	5	53	37	97	57
CBO Total	3	1	14	10	1	1	4	2	6	5	6	3	34	22
NGO Total	4	3	4	1	5	5	1	1	0	0	3	1	17	11
TOTAL	76	18	155	69	35	18	118	57	42	27	201	107	627	296

Table IV: Partnerships by leading actor and partner (number of initiatives)

Partners	Local government	Sub-national	National Government	International Organisation	Private	NGO	CBO	Total
Local Government	4	3	7	2	8	5	13	42
Sub-national government	0	0	0	0	3	0	1	4
National government	14	0	0	0	3	1	0	18
International Organisation	15	3	3	0	4	2	0	27
Private	112	4	8	0	37	2	6	169
NGO	5	0	1	0	1	0	1	8
CBO	21	0	1	0	1	1	1	25
University	3	0	0	0	0	0	0	3
No partnership	239	10	22	2	40	6	12	331

Figure 1: Sample Cities

